

SHORT COMMUNICATION

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A Possible Explanation of the Effects of Noise and Vibration on Hearing

Próba wyjaśnienia wpływu hałasu i wstrząsów na słuch

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In contrast to the widely discussed harmful effects of noise on the hearing organ, the role of vibration has remained largely elusive, and frequently disregarded. In the professional literature on the subject, the opinion is generally accepted that vibration exerts only a weak harmful influence on hearing. Here the authors describe the results of an experiment designed to investigate one of the effects of noiseless vibration and offer an explanation of the link between noise and vibrational damage.

In industrialized countries, millions of workers use hand-held vibrating tools [1]. The number of those subjected to whole-body vibration is several times larger, as nearly everyone, e.g. those using any sort of transportation, is exposed to vibration [2]. Because most machines produce noise, it is the combined effects of both factors, noise and vibration, which are usually examined. Their traumatic influence (as in the case of noise) is usually attributed to demonstrable damage to sensory cells of the inner ear [3]. But there are also reports of the expressly injurious effects of vibration on industrial workers. They describe more advanced hearing trauma in a wide frequency range among drivers and operators of vibrating tools than among persons exposed to noise only [4, 5].

Authors' aim was to investigate experimentally the influence of long-term whole-body noiseless vibration on the incudostapedial joint of the middle ear. The flexibility of the joint separates the inner ear from the considerable dislocations of the tympanic membrane. Its immobilization can be elusive on an audiogram; however, its integrity is indispensable in protecting the inner ear from the effect of noise. The considerable distance of the ear from the sources of applied vibration has dis-

couraged searching for possible damage to the auditory ossicles up to now.

Material and Methods

The authors chose guinea pigs for the experiment, as they have a hearing range similar to man's [6]. The Local Ethics Committee in Wrocław approved the experiments, and the "Principles of Laboratory Animal Care" were followed as well. Ten animals were subjected to vertical sinusoidal shaking common in transportation (10 Hz vibration at $1.4 \times g$ rms) in a cage fastened to a noiseless impulse exciter. The effective experimental duration was 12 working weeks (5 days/week, 6 hours/day). After the experiment, the authors collected the auditory ossicles from each animal, and a scanning microscope was used to examine the 20 incudostapedial joints.

Results

Six of the joints could not be opened due to the considerably thickened capsules surrounding the joint. The authors obtained stapes with a bilaterally separated lenticular process (a fragment of the incus) in one guinea pig and unilaterally in four, making the articular surfaces inaccessible. Six of the opened joints also showed distinct thickening of the capsules. In five of the fourteen opened joints (two with thickened capsules), the authors also detected degenerative changes on the articular surfaces, e.g. fissures and craters of varying size. In only five joints were neither thickened capsules nor changes on the cartilage surfaces detected.

Table 1. Damages to the incudo-stapedial joint which can be attributed to the activity of vibration

Thickening of the bursa		Disintegration of the surface		Normal joint	
N	%	N	%	N	%
12	60	6	43	5	25

Contraction of the stapedius muscle causes a sliding movement in the incudostapedial joint, limiting the mobility of the footplate of the stapes in the oval window, thus diminishing the transmission of sound [7]. This protective activity of the stapedius reflex also dampens the injurious effects of industrial noise [8]. Degenerative articular changes negatively influence the decoupling of the joint and probably facilitate the transmission of noise, and its effects, to the inner ear. Such a mechanism seems to be the most probable explanation of the synergistic activity of both factors dangerous to hearing: noise and vibration.



Fig. 1. Vibrational changes in the incudostapedial joint: a) thickened joint capsule from the side of the incus; b) degenerative changes on the surface of the osteoarthritic cartilage

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